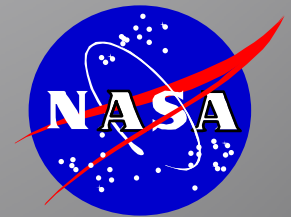


ENGINEERING ABOVE AND BEYOND

Written communication in the technical workplace...

Vanderbilt University
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Contents

- Environmental control and life support systems (ECLSS)
 - Some basics
- How does effective written communication fit?
 - The fundamentals
- Conclusion
- Helpful sources



The Daily Challenge

Inputs

- Oxygen
0.84 kg (1.84 lb)
- Food Solids
0.62 kg (1.36 lb)
- Water in Food
1.15 kg (2.54 lb)
- Food Prep Water
0.76 kg (1.67 lb)
- Drink
1.62 kg (3.56 lb)
- Metabolized Water
0.35 kg (0.76 lb)
- Hand/Face Wash Water
4.09 kg (9.00 lb)
- Shower Water
2.73 kg (6.00 lb)
- Urinal Flush
0.49 kg (1.09 lb)
- Clothes Wash Water
12.50 kg (27.50 lb)
- Dish Wash Water
5.45 kg (12.00 lb)

Total = 30.60 kg (67.32 lb)



Outputs

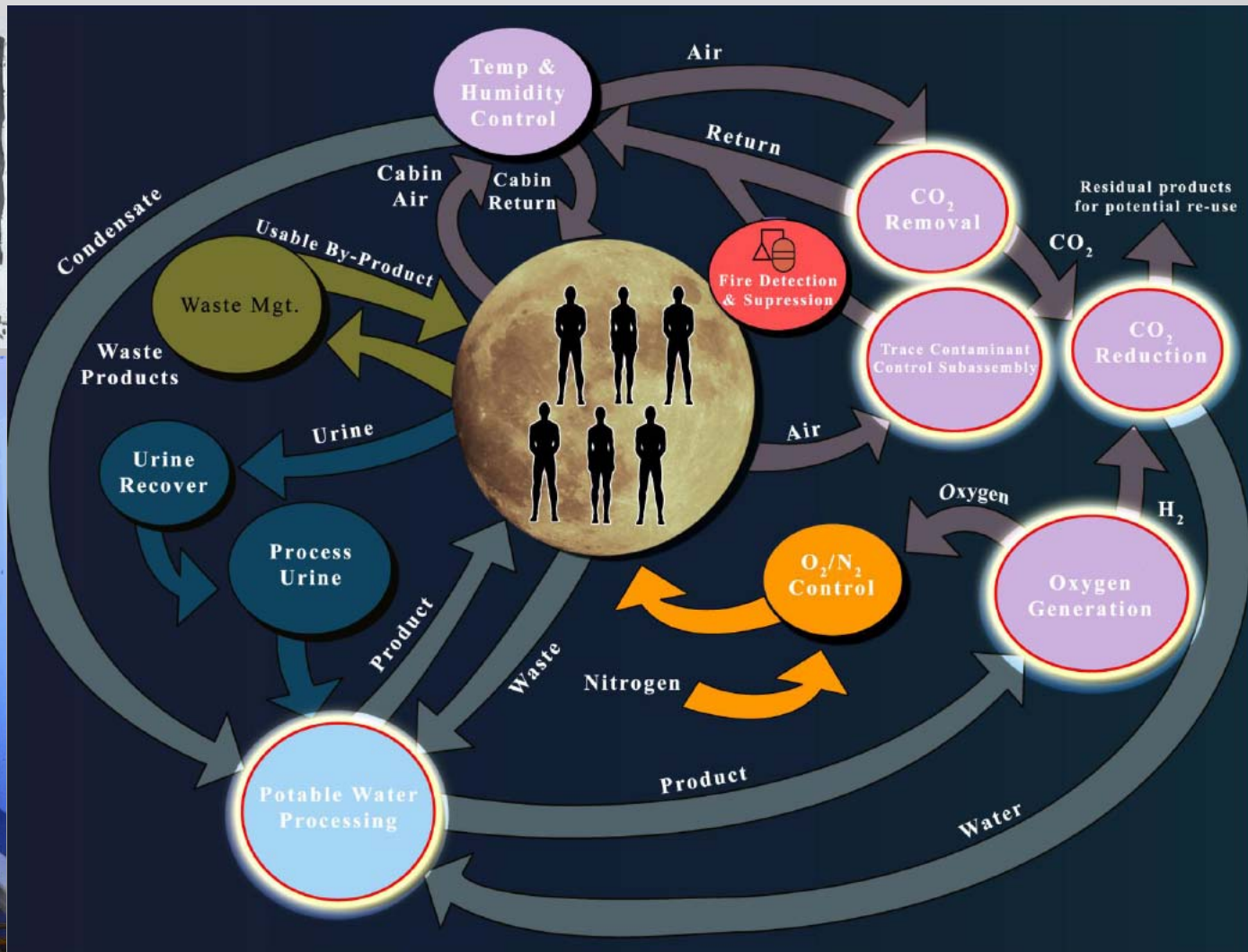
- Carbon Dioxide
1.00 kg (2.20 lb)
- Respiration & Perspiration Water
2.28 kg (5.02 lb)
- Food Preparation, Latent Water
0.036 kg (0.08 lb)
- Urine
1.50 kg (3.31 lb)
- Urine Flush Water
0.49 kg (1.09 lb)
- Feces Water
0.091 kg (0.20 lb)
- Sweat Solids
0.018 kg (0.04 lb)
- Urine Solids
0.059 kg (0.13 lb)
- Feces Solids
0.032 kg (0.07 lb)
- Hygiene Water
12.58 kg (27.68 lb)
- Clothes Wash Water
11.90 kg (26.17 lb) liquid
0.60 kg (1.33 lb) vapor

Total = 30.60 kg (67.32 lb)

ECLS System Functions

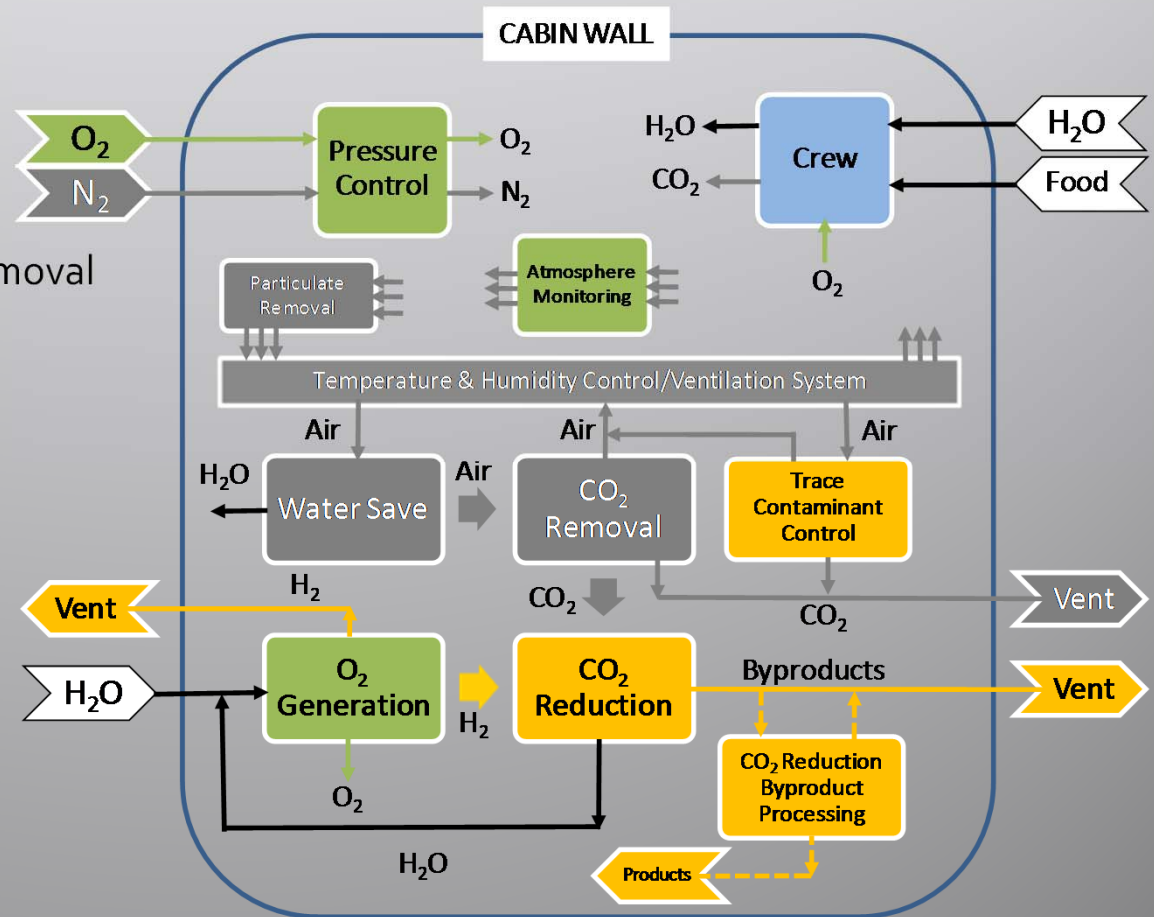
Control Atmosphere Pressure	Condition Atmosphere	Respond to Emergency Conditions	Control Internal CO ₂ & Contaminants	Provide Water	Prepare for EVA Operations
<ul style="list-style-type: none"> • O₂/N₂ Pressure Control Assemblies (USO/RS) • Positive & Negative Pressure Relief (USOS-Transport) • O₂/N₂ Storage (USOS, RS, Progress) • O₂ Generation Assembly, O₂ Solid Chemicals (RS) • Major Constituent Analyzer (USOS) (Share) • Gas Analyzer (RS) (Shared) 	<ul style="list-style-type: none"> • Cabin Air Temperature & Humidity Control Assemblies (All) • Ventilation Fans (USOS, RS, MPLM) • Air Particulate Filters (All) • Intermodule Ventilation Fans & Valves (All) • Ducting (All) 	<ul style="list-style-type: none"> • Smoke Detectors (All) • Portable Fire Extinguishers (All) • Fire Indicators and Fire Suppression Ports (All) • Portable Breathing Apparatus and Masks (All) • O₂/N₂ Pressure Control Assemblies (USOS) (Shared) 	<ul style="list-style-type: none"> • CO₂ Removal Assembly (USOS/RS) • CO₂ Vent (USOS/RS) • Trace Contaminant Control Assembly (USOS/RS) • Major Constituent Analyzer (USOS) • CO₂ Reduction Assembly (RS) • CO₂ LIOH Removal (RS) • Manual Sampling Equipment (USOS) • Gas Analyzer (RS) 	<ul style="list-style-type: none"> • Potable Water Processor (USOS/RS) • Urine Processor (USOS/RS) • Process Control Water Quality Monitor (USOS) • Condensate Storage (USOS/RS) • Fuel Cell Water Storage (USOS) • Waste Water Distribution (USOS) • Hygiene Water Processor (RS) 	<ul style="list-style-type: none"> • O₂/N₂ Pressure Control Assemblies (USOS) • O₂/N₂ Distribution (USOS) • O₂/N₂ Storage (USOS) • Major Constituent Analyzer (USOS) (Shared)
Atmosphere Control & Supply (ACS) & AR	Temperature Humidity Control	Fire Detection & Suppression & ACS	Atmosphere Revitalization (AR)	Water Recovery & Mgmt/ Waste Mgmt	ACS & AR

ECLS System Functional Interactions

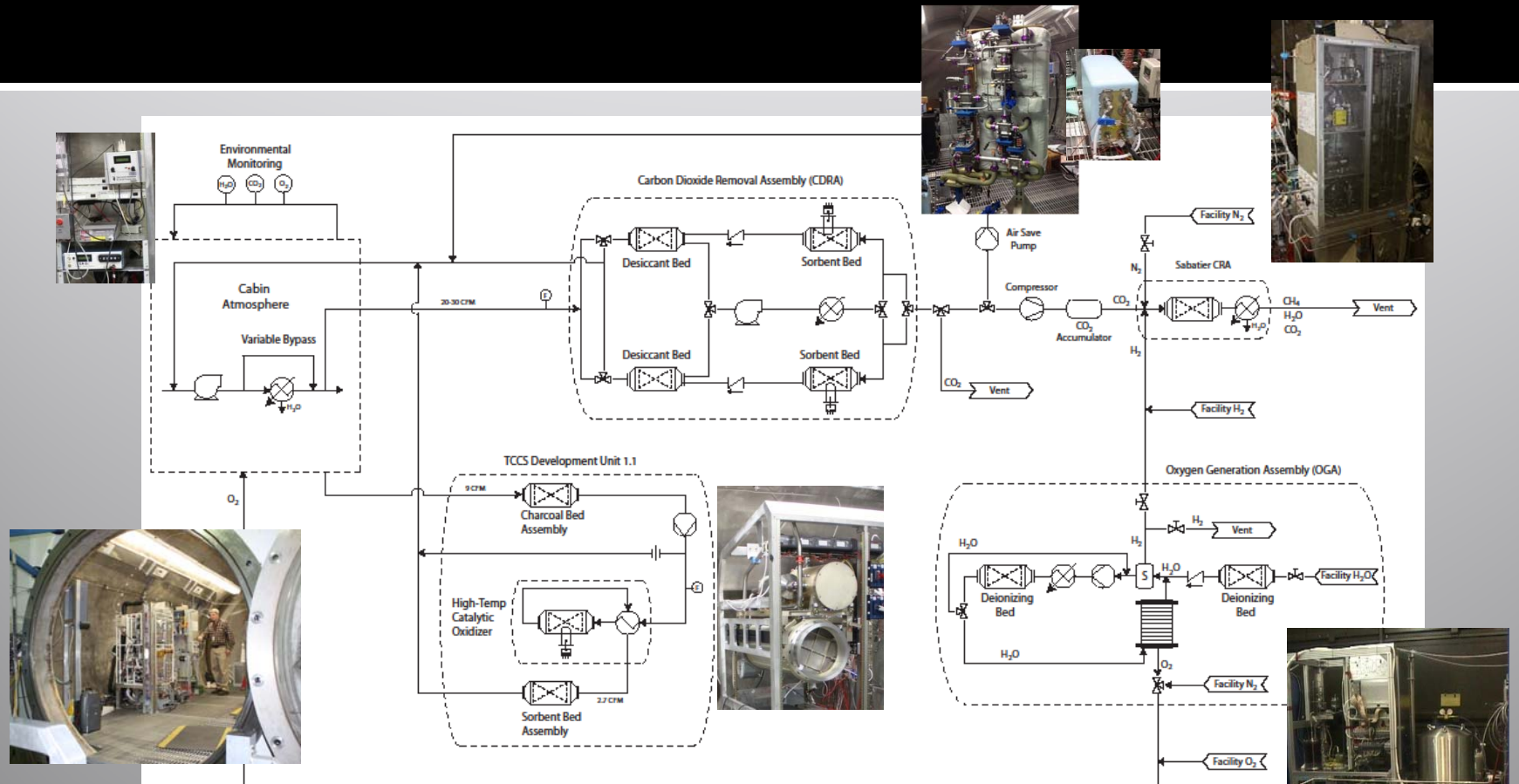


Process Types & Unit Operations

- Separations
 - Physical adsorption
 - Process gas drying
 - CO₂ removal
 - Gaseous contaminant removal
 - Absorption
 - Filtration
- Reactions
 - Chemical adsorption
 - Catalytic oxidation
 - Catalytic reduction
 - Electrochemical
 - Plasma
- Resource management
 - Gas storage & conditioning
 - Atmospheric gas production & recycling



ISS AR Process Architecture



ISS Performance Basis
Hardware Schematic
Draft 4
5-15-2012

Symbols

	Packed bed		Check valve		Pump		Electrolysis Stack
	Heater		Three-way automatic control valve		Compressor		Accumulator
	Cooler		Two-way hand-operated valve		Blower		Separator
	Recuperative Heat exchanger		Dewpoint analyzer		Flowmeter		Orifice
	Condensing Heat exchanger		Carbon dioxide analyzer		Oxygen analyzer		

Successful Engineering...

or any worthwhile endeavor requires...

COMMUNICATION

“When I began working in industry, I learned quickly how written communication is tremendously important. An engineer can have great ideas or work, but ideas will never get implemented or noticed if they are not communicated to those who make the decisions.”

Gregory N. Tragitt, BE’78
Vanderbilt Engineering, Fall 2011

“Give me six hours to chop down a tree and I will spend the first four sharpening the axe.”

Abraham Lincoln

Communicating is a Process...



Technical Writing Products

TECHNICAL

- **Specifications and standards**
 - *Performance*
 - *Interfaces*
 - *Environments*
 - *Materials*
 - *ISO 9000 certification*
- **Architectural descriptions**
- **Operations documents**
 - *Procedures*
 - *Manuals*
- **Developmental documents**
 - *Experiment requirements*
 - *Experiment procedures*
 - *Technical reports*
 - *Intellectual property*

CONTRACTUAL

- **Customer**
 - *Statement of work*
 - *Request for proposal*
 - *Technical evaluation*
 - *Contracts and protocols*
 - *Task agreements*
 - *Memoranda of agreement*
- **Product Provider**
 - *Proposals*
 - *Contracts and protocols*
 - *Technical reports*

OTHER FORMS

- **Product brochures**
- **Product technical literature**
- **News items**
- **Status reports**
- **Meeting minutes**
- **Letters**
 - *transmittal*
 - *informative*
 - *persuasive*

NASA/TM—2005–214061



Thermal Catalytic Oxidation of Airborne Contaminants by a Reactor Using Ultra-Short Channel Length, Monolithic Catalyst Substrates

(MSFC Center Director's Discretionary Fund Final Report, Project No. 02–18)

J.L. Perry and K.M. Tones
Marshall Space Flight Center, Marshall Space Flight Center, Alabama

J.D. Tataru
Qualis Corporation, Huntsville, Alabama

September 2005

Vital Writing Elements



Impediments to Effective Writing



Personal

- Do not like to write—it's hard, not fun

Organizational

- Project views as unimportant
- Pressure to move to next task

Budget

- No project resources allotted (time)

Schedule

- Planning and priorities

Cultural

- Perception there is no reward

Consequences

THE JOB IS NOT FINISHED

No job is complete without the final report!



THE PRODUCT FAILS

The service does not meet customer needs

The contract does not deliver what it should

The equipment does not work as desired



LOSSES MOUNT

Time and money

Corporate memory

Operational control

Configuration control

Equipment damage

LIVES CAN BE LOST!

The Shuttle *Columbia*—Findings from the CAIB

“The Board views the endemic use of PowerPoint briefing slides instead of technical papers as an illustration of the problematic methods of technical communication at NASA.” – CAIB Report

ENGINEERING BY VIEWGRAPHS

The Debris Assessment Team presented its analysis in a formal briefing to the Mission Evaluation Room that relied on Power Point slides from Boeing. When engineering analyses and risk assessments are condensed to fit on a standard form or overhead slide, information is inevitably lost. In the process, the priority assigned to information can be easily misrepresented by its placement on a chart and the language that is used. Dr. Edward Tufte of Yale University, an expert in information presentation who also researched communications failures in the *Challenger* accident, studied how the slides used by the Debris Assessment Team in their briefing to the Mission Evaluation Room misrepresented key information.³⁸

The slide created six levels of hierarchy, signified by the title and the symbols to the left of each line. These levels prioritized information that was already contained in 11 simple sentences. Tufté also notes that the title is confusing: "Review of Test Data Indicates Conservatism" refers not to the predicted title damage, *but to the choice of test models used to predict the damage.*

Only at the bottom of the slide do engineers state a key piece of information: that one estimate of the debris that struck *Columbia* was 640 times larger than the data used to calibrate the model on which engineers based their damage assessments. (Later analysis showed that the debris object was actually 400 times larger). This difference led Tufte to suggest that a more appropriate headline would be "Review of Test Data Indicates Irrelevance of Two Models."³⁰

Tufte also criticized the sloppy language on the slide. "The vaguely quantitative words 'significant' and 'significantly' are used 5 times on this slide," he notes, "with de facto meanings ranging from 'detectable in largely irrelevant calibration case study' to 'an amount of damage so that everyone dies' to 'a difference of 640-fold.'"⁴⁰ Another example of sloppiness is that "cubic inches" is written inconsistently: "3cu. in., 1920cu.in., and 3cu in." While such inconsistencies might seem minor, in highly technical fields like aerospace engineering a misplaced decimal point or mistaken unit of measurement can easily engender inconsistencies and inaccuracies. In another phrase "Test results do show that it is possible at sufficient mass and velocity," the word "it" actually refers to "damage to the protective tiles."

As information gets passed up an organization hierarchy, from people who do analysis to mid-level managers to high-level leadership, key explanations and supporting information is filtered out. In this context, it is easy to understand how a senior manager might read this PowerPoint slide and not realize that it addresses a life-threatening situation.

At many points during its investigation, the Board was surprised to receive similar presentation slides from NASA officials in place of technical reports. The Board views the endemic use of PowerPoint briefing slides instead of technical papers as an illustration of the problematic methods of technical communication at NASA.

- Analysis findings presented in management briefing
- Title is confusing
- Inevitable Information loss
- Key information is misrepresented and demoted in hierarchy
- Most important item buried at the bottom of the slide
- Vaguely quantitative wording used
 - “Significantly” used 6 times to mean different things
- Inconsistent units of measure

Review Of Test Data Indicates Conservatism for Tile Penetration

- The existing SOFI on tile test data used to create Rater was reviewed along with STS-167 Southwest Research data
 - Greater overpredicted penetration of tile coating
- **Significantly**
 - **Significant** penetration to described by normal velocity
 - Varies with voluminosities of propellant g, 2000ft/s
 - **Significant** energy is required for the softer SOFI **outlets** to penetrate the relatively hard tile coating
 - Test results do show that **penetration** at sufficient mass and velocity
 - **Conversely**, once tile is penetrated SOFI can cause **significant damage**
 - Minor variations in total energy (above penetration level) can cause **significant** the damage
- Flight conditions is significant to the design of test database
 - Volume of ramp is 1920cm in vs 3 cm in for test

The vaguely quantitative words **significant** and **significantly** are used 5 times on this slide, with *de facto* meanings ranging from "detectable in largely irrelevant calibration case study" to "an amount of damage so that everyone dies" to "a difference of 640-fold." None of these 5 usages appears to refer to the technical meaning

- The low resolution of PowerPoint slides promotes the use of compressed phrases like "Tile Penetration.*" As is the case here, such phrases may well be ambiguous. (The low resolution and large font generate 3 typographic orphans, lonely words dangling on a separate line.)

This vague pronoun reference "it" alludes to damage to the protective tiles, which caused the destruction of the Columbia. The slide weakens important material with ambiguous language (sentence fragments, passive voice, multiple meanings of "significant"). The 3 reports were created by engineers for high-level NASA officials who were deciding whether the threat of wing damage required further investigation before the Columbia attempted return. The officials were satisfied that the reports indicated that the Columbia was not in danger, and was safe to fly. The slide was part of an oral presentation made. The slides were part of an oral presentation and also were circulated as e-mail attachments.

The analysis by Dr. Edward Tufte of the slide from the Debris Assessment Team briefing. [SOFI=Spray-On Foam Insulation]

Conclusion

- Writing is essential to technical success
 - Provides a foundation for other means of communication
 - Preserves corporate memory
 - Ensures that you get what you pay for
- Successful writing takes time
 - More than 90% of a job may be dedicated to documentation in some form
 - Practice by doing
- Strive to overcome obstacles
 - Set aside time to plan
 - Ensure project resources and schedules allow adequate time
 - Recognize that the rewards are gained over time as your products establish your credibility

